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MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO) 27 June 2002

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-167**
C.T. Liu (PRSM) et al., "IEstimating the Equivalent Initial Crack Size in a Particulate Composite Material under a Multi-Axial Loading Condition" (viewgraphs)

**Int'l Conf. on Computational Engineering & Science** **(Statement A)**
**(Reno, NV, 31 July – 02 August 2002) (Deadline: 30 July 2002)**

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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

# Estimating the Equivalent Initial Crack Size in a Particulate Composite Material under a Multi-Axial Loading Condition


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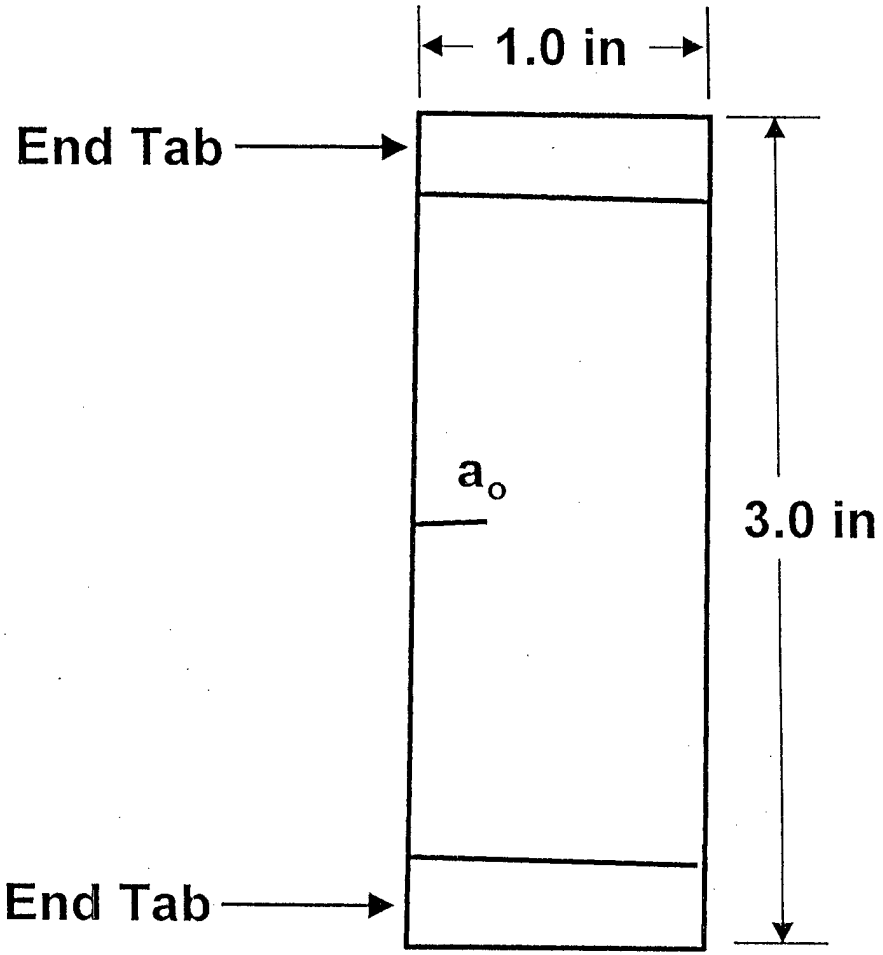
# Objectives

- Investigate the Effect of Confined Pressure on the Equivalent Initial Crack Size in a Particulate Composite Material under a Constant Strain Rate of 18.18 in/in/min.
  - Confined Pressures: Ambient and 1000 psi
- Determine the Statistical Distribution Function of the Equivalent Initial Crack Size.
  - Normal Distribution
  - Two-Parameter Lognormal Distribution
  - Two-Parameter Weibull Distribution
  - Second Asymptotic Distribution of the Maximum Value

# Specimen Geometry



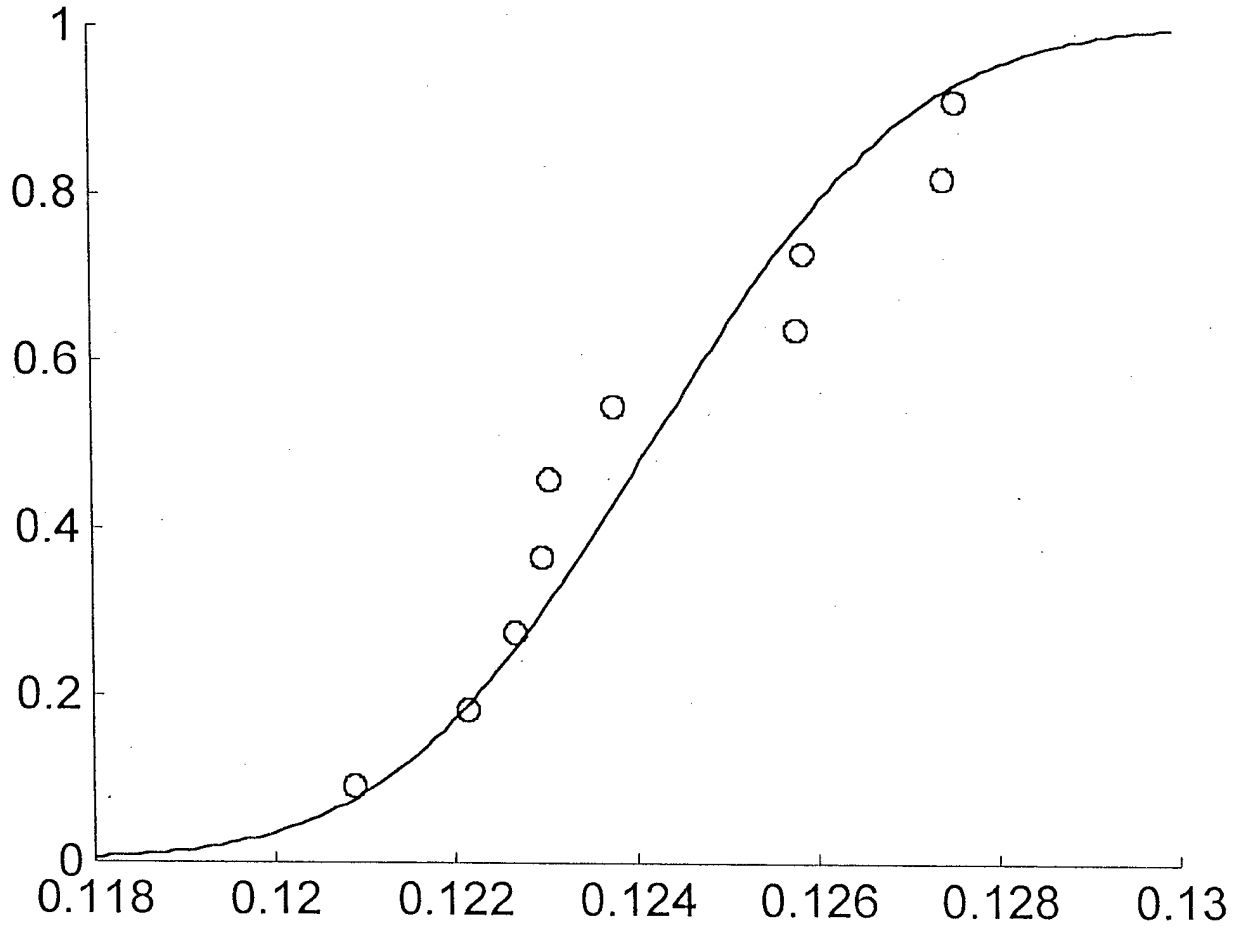
# Summary of Crack Lengths (Ambient Pressure)

| Specimen | $a_c$ | $t_c$(sec) | $a^*$ | $t^*$ (sec) | $a_0$ |
|---|---|---|---|---|---|
| Specimen 2 | 0.15425 | 1.52410 | 0.14396 | 0.92817 | 0.14258 |
| Specimen 3 | 0.15543 | 1.56840 | 0.14530 | 0.97216 | 0.14386 |
| Specimen 4 | 0.15993 | 1.62110 | 0.15018 | 1.04930 | 0.14888 |
| Specimen 5 | 0.15268 | 1.47570 | 0.14237 | 0.88766 | 0.14114 |
| Specimen 6 | 0.15476 | 1.45990 | 0.14506 | 0.89909 | 0.14379 |
| Specimen 7 | 0.15505 | 1.46360 | 0.14471 | 0.87206 | 0.14348 |
| Specimen 8 | 0.16073 | 1.50860 | 0.15029 | 0.89749 | 0.14883 |
| Specimen 9 | 0.16006 | 1.49300 | 0.14973 | 0.88745 | 0.14826 |
| Specimen 10 | 0.15765 | 1.50720 | 0.14717 | 0.89387 | 0.14575 |
| Specimen 11 | 0.15902 | 1.52830 | 0.14858 | 0.91423 | 0.14711 |
| Specimen 12 | 0.16086 | 1.49390 | 0.15115 | 0.92008 | 0.14976 |
| Specimen 13 | 0.15963 | 1.47920 | 0.14965 | 0.89482 | 0.14819 |

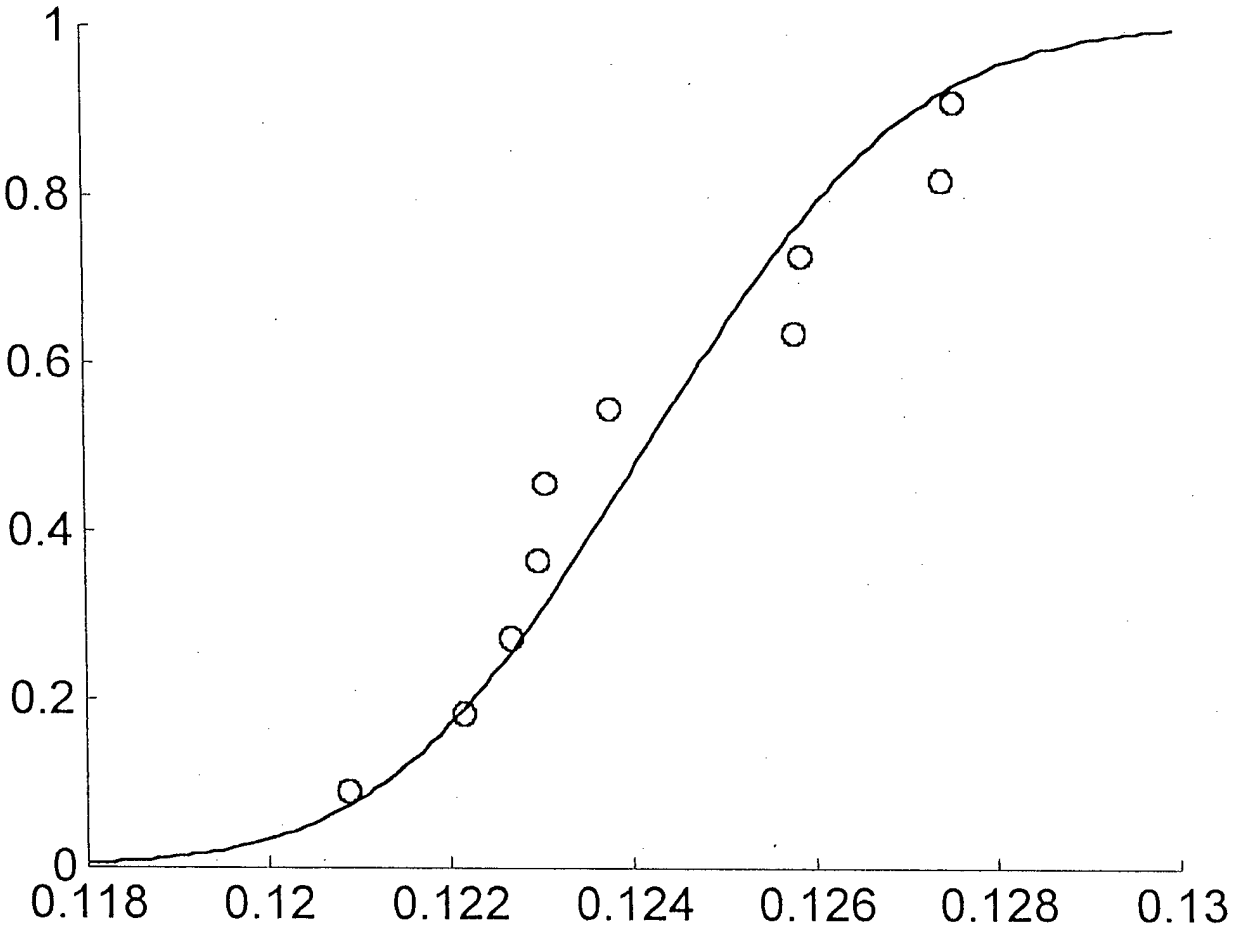
# Summary of Crack Lengths (1000 psi Pressure)

| Specimen | $a_c$ | $t_c$(sec) | $a^*$ | $t^*$ (sec) | $a_0$ |
|---|---|---|---|---|---|
| Specimen 1 | 0.13691 | 1.39630 | 0.12298 | 0.77889 | 0.12192 |
| Specimen 2 | 0.13782 | 1.42730 | 0.12268 | 0.76981 | 0.12158 |
| Specimen 3 | 0.14140 | 1.52430 | 0.12744 | 0.90516 | 0.12641 |
| Specimen 4 | 0.14225 | 1.45830 | 0.12760 | 0.81887 | 0.12651 |
| Specimen 5 | 0.13629 | 1.43770 | 0.12089 | 0.76950 | 0.11979 |
| Specimen 6 | 0.13644 | 1.40720 | 0.12216 | 0.77942 | 0.12109 |
| Specimen 7 | 0.13812 | 1.38830 | 0.12379 | 0.76062 | 0.12271 |
| Specimen 8 | 0.13994 | 1.37600 | 0.12581 | 0.75726 | 0.12472 |
| Specimen 9 | 0.14072 | 1.43480 | 0.12589 | 0.79079 | 0.12480 |
| Specimen 10 | 0.13765 | 1.44890 | 0.12307 | 0.80817 | 0.12199 |

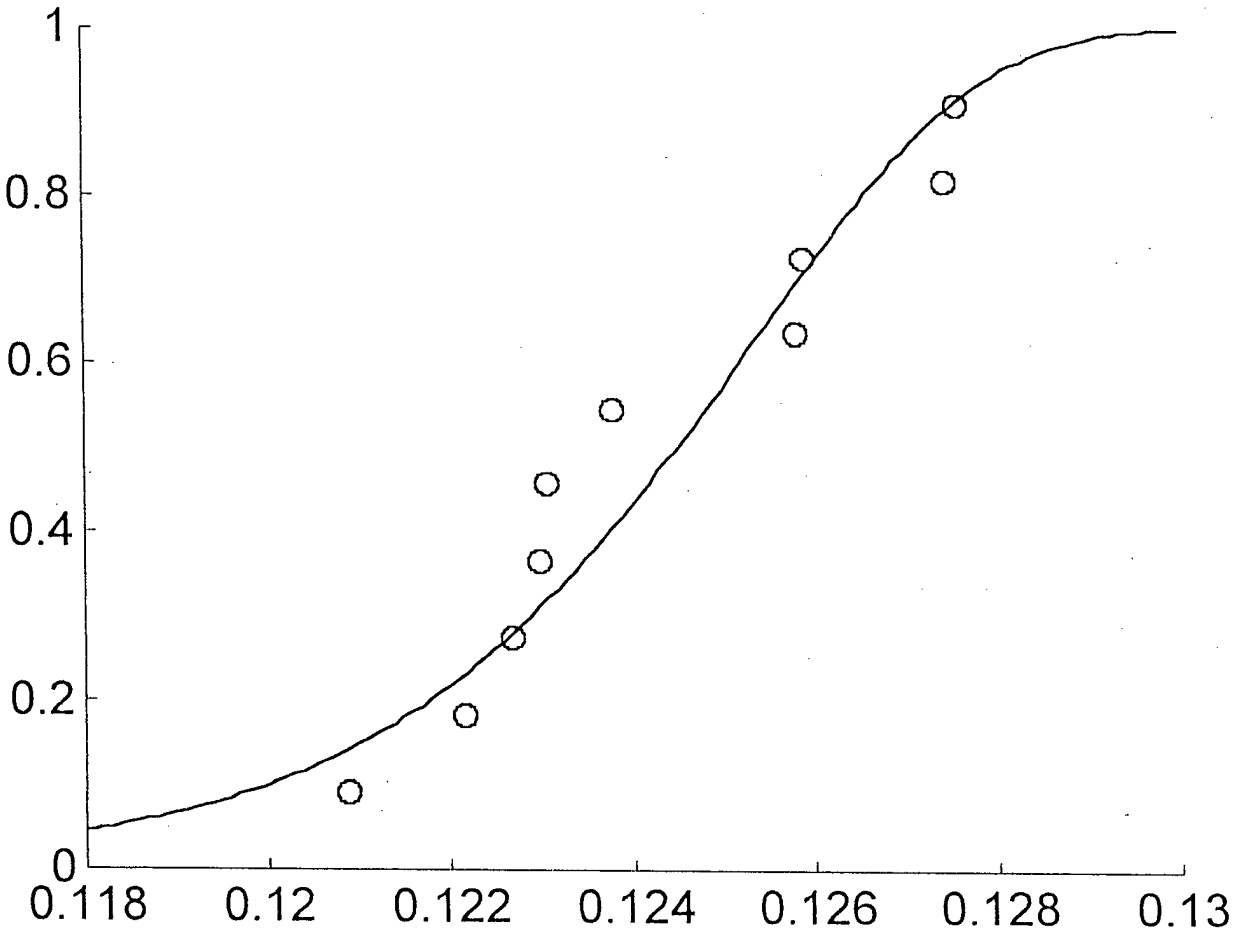
# Normal Distribution Plot for a *



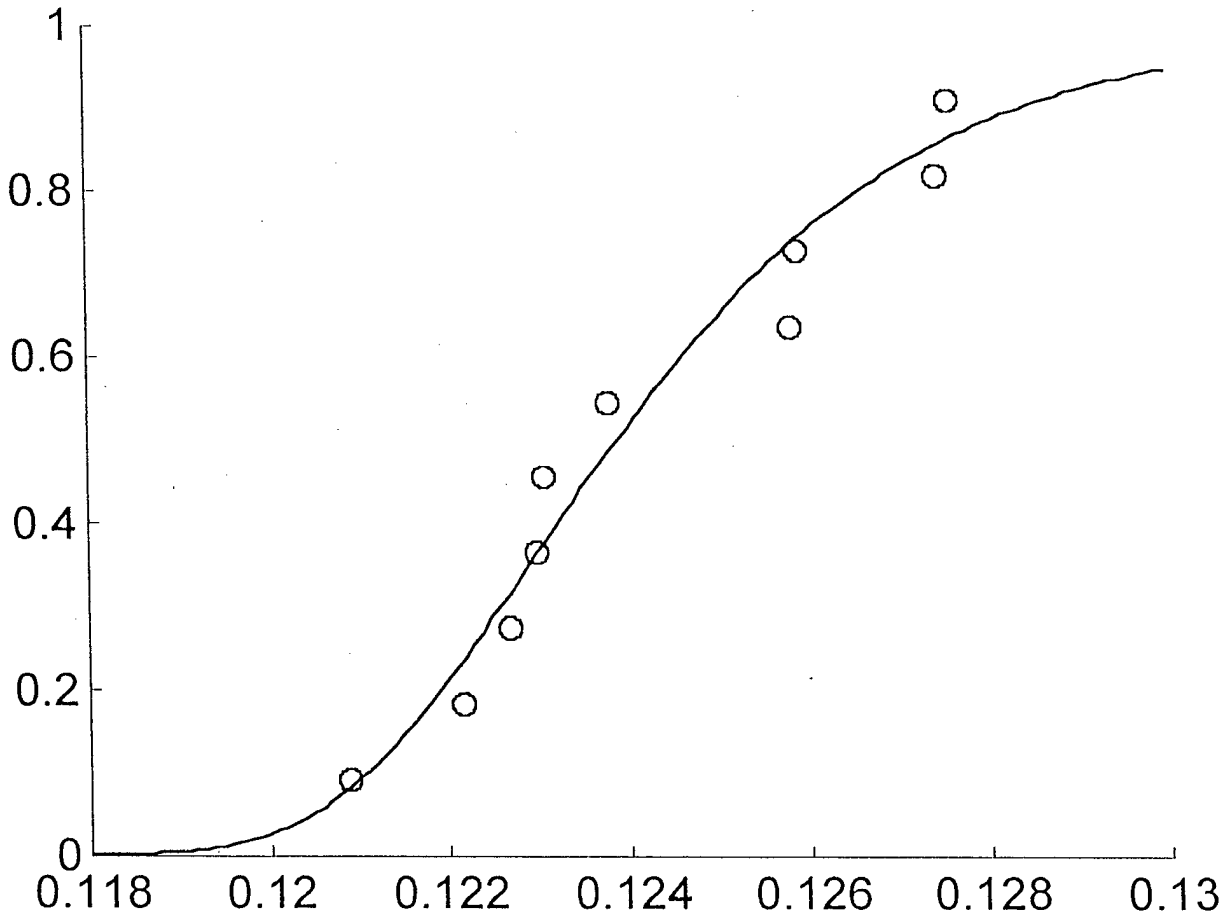
# Lognormal Distribution Plot for a *



# Weibull Distribution Plot for a *



# Second Asymptotic Distribution of Maximum Value Plot for a *



# Distribution Parameters for Normal, Two-Parameter Lognormal, Two-Parameter Weibull, and Second Asymptotic Distribution of Maximum Value
## ( Ambient Pressure)

| | $a_c$ | $a^*$ | $a_0$ |
|---|---|---|---|
| $\mu$ | 0.15750 | 0.14735 | 0.14597 |
| $\sigma$ | 0.00290 | 0.00296 | 0.00290 |
| $\mu^*$ | -1.84847 | -1.91517 | -1.92456 |
| $\sigma^*$ | 0.01842 | 0.02008 | 0.01989 |
| $\alpha$ | 53.6601 | 49.5994 | 50.0668 |
| $\beta$ | 0.1590 | 0.1488 | 0.1474 |
| $\kappa$ | 51.3708 | 47.7906 | 48.4144 |
| $\nu$ | 0.1559 | 0.1458 | 0.1444 |

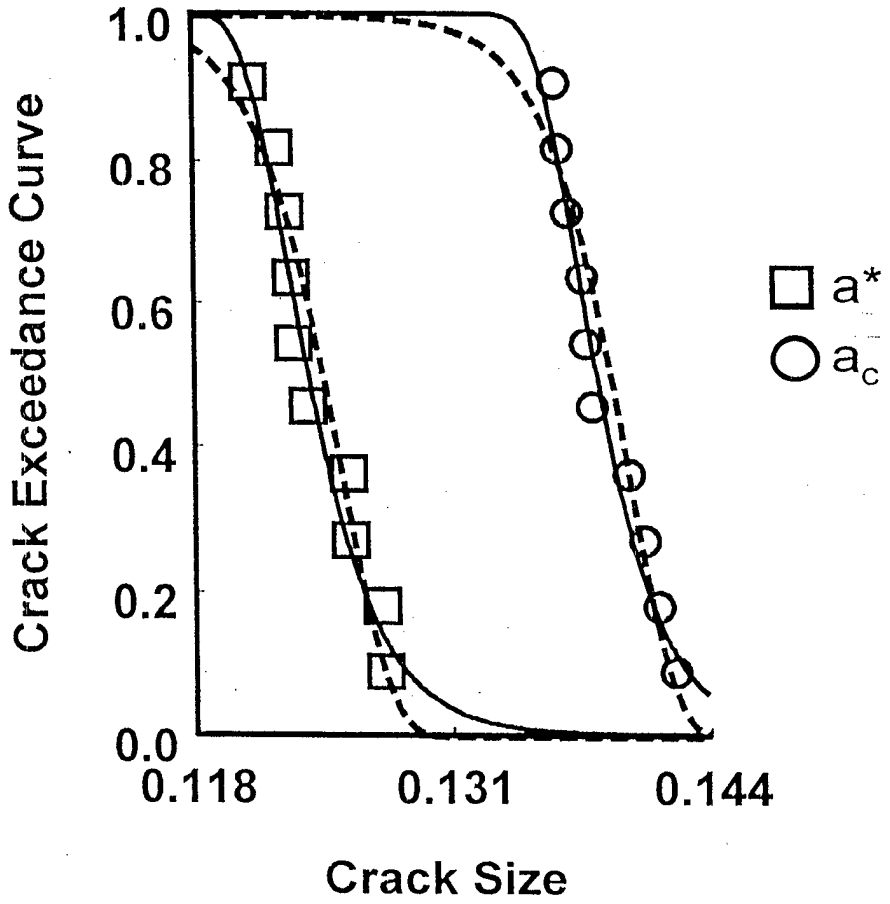
# Distribution Parameters for Normal, Two-Parameter Lognormal, Two-Parameter Weibull, and Second Asymptotic Distribution of Maximum Value

(1000 psi Pressure)

| | $a_c$ | $a^*$ | $a_0$ |
|---|---|---|---|
| $\mu$ | 0.13875 | 0.12423 | 0.12315 |
| $\sigma$ | 0.00216 | 0.00231 | 0.00231 |
| $\mu^*$ | -1.97517 | -2.08578 | -2.09451 |
| $\sigma^*$ | 0.01553 | 0.01856 | 0.01878 |
| $\alpha$ | 60.3527 | 51.4485 | 50.8397 |
| $\beta$ | 0.1399 | 0.1254 | 0.1243 |
| $\kappa$ | 63.2361 | 52.4640 | 51.8168 |
| $\nu$ | 0.1377 | 0.1230 | 0.1220 |

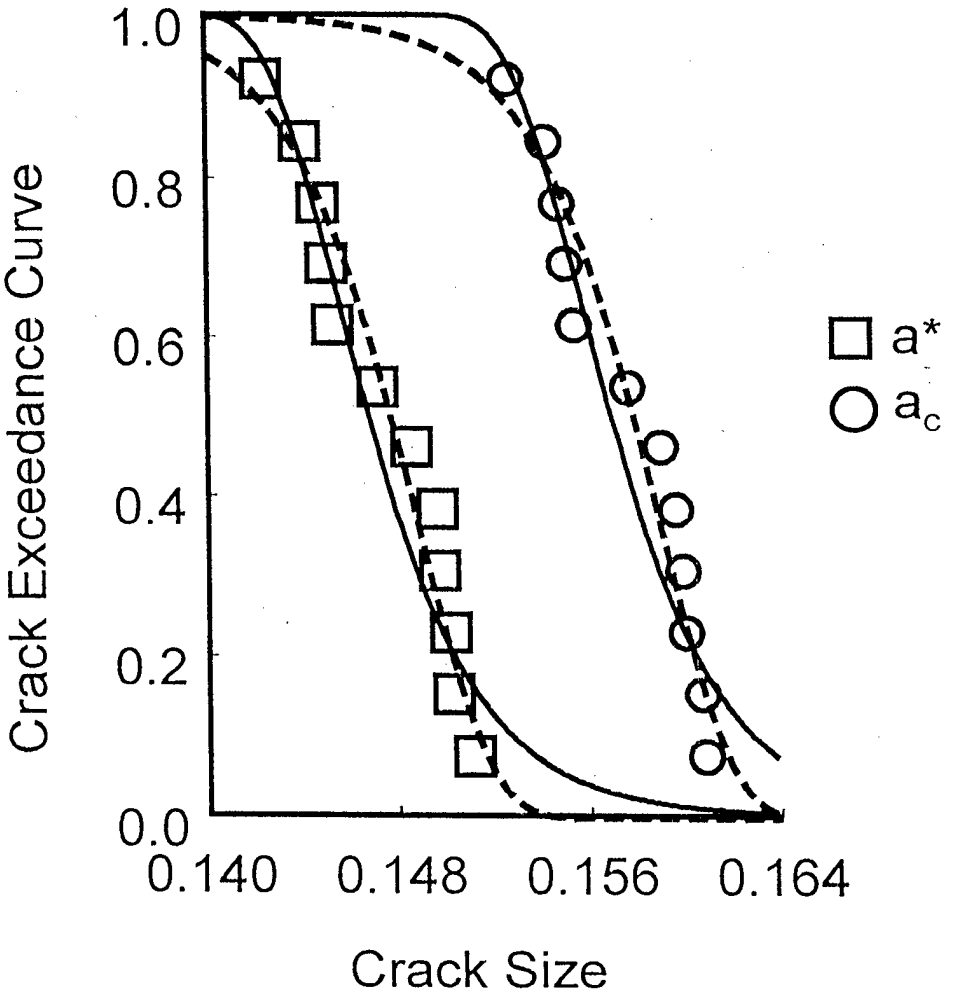
# Crack Exceedance Curves for Equivalent Initial Crack Size and Critical Crack Size ( Strain Rate 18.18 min-1; 1000 psi Pressure);

Solid Curves for Second Asymptotic Distribution of Maximum Value and Dashed Curves for Weibull Distribution

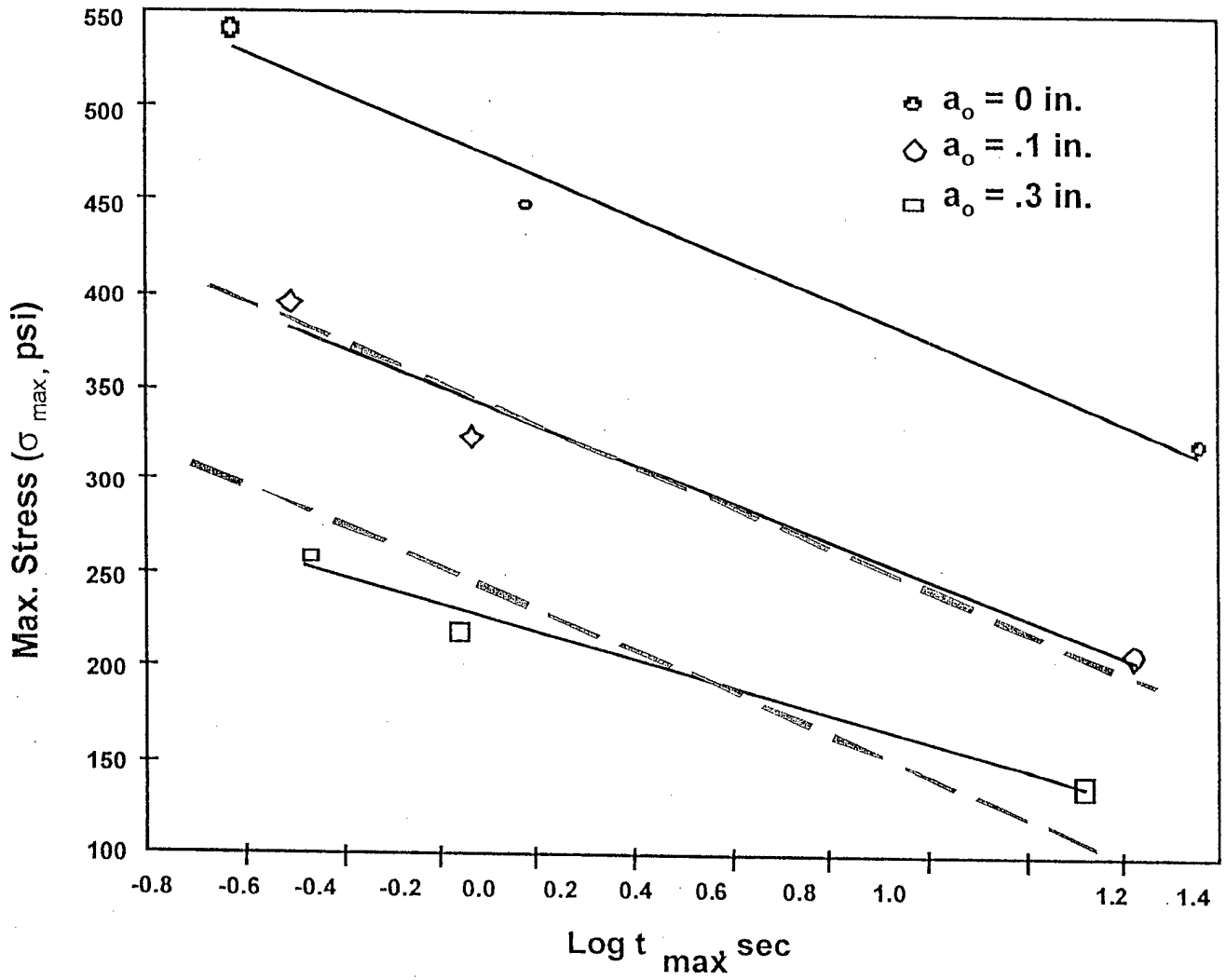


# Crack Exceedance Curves for Equivalent Initial Crack Size and Critical Crack Size ( Strain Rate 18.182 min-1; Ambient Pressure)

Solid Curves for Second Asymptotic Distribution of Maximum Value and Dashed Curves for Weibull Distribution



# Maximum Stress Versus Maximum Time



# Conclusions

1. For the material investigated, confined pressure has no significant effect on the equivalent initial crack size.
2. The predicted equivalent initial crack size compares well with experimental value.
3. The predicted equivalent initial crack size follows the second asymptotic distribution of maximum value.